

SOME ASPECTS OF MECHANISMS OF NaCl STRESS TOLERANCE IN THE SEEDLINGS OF FOUR RICE GENOTYPES

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Abstract

Biomass production under salt stress decreased with the sequence: IRATOM-24 > BR 9 > Nonabokra > Pokkali. In Pokkali root-shoot dry wt. was less affected and it maintained high root to shoot ratio (R/S) and their tolerance indices (TI). Salinity stress increased Na⁺, Cl⁻ and decreased K⁺ and Ca²⁺ contents and consequently their ratios in both root and shoot of the seedlings. Under stress proline level was increased in both root and shoot of the seedlings in all genotypes, the highest was observed in the root of Pokkali and in the shoot of IRATOM-24. Excepting BR 9 salinity increased protein content in other genotypes and among them Nonabokra maintained the highest protein level. Salinity inhibited the root ATPase activity in all except Pokkali. Efficiency of the maintenance of relatively high dry matter, R/S ratio, essential ions, K⁺ - Ca²⁺ / Na⁺ ion ratios, proline and protein contents in the seedlings including the root ATPase activity may be important aspects of NaCl stress tolerance mechanism as found in one or another rice genotype of the present work.

Salinity is a world-wide problem and more than 60 million ha rice growing lands of the world are salt affected (Jennings *et al.* 1979). Rice is salt sensitive but its germplasms reveal differential responses (Yeo *et al.* 1990) and the general threshold of NaCl tolerance is insignificant e.g. - 4 dS.m⁻¹ conductivity compared to either of light, moderate and high saline soil conductivity e.g. 4 - 8, 8 - 15 and >15 dS.m⁻¹ respectively. Salinity by osmotic shock and ion toxicity affects physiological and biochemical processes resulting in suboptimal plant growth and yield (Gilbert *et al.* 1997). Both Na⁺ and Cl⁻ ions disrupt the basic feature of protein, enzyme as well as plasma membrane. The physiology and biochemistry of salt tolerance mechanism in rice is poorly understood, but the characters associated with salt tolerance could be identified and their systematic investigation could lead to the exploration of the mechanism of salt tolerance. In the present work some attributes associated with NaCl stress tolerance in the seedling of four rice genotypes were investigated.

Four rice (*Oryza sativa* L.) genotypes (BR-9 and IRATOM-24 - high yielding salt sensitive, and Nonabokra and Pokkali - salt tolerant varieties) were taken and their 20 days old seedlings were grown in 8L plastic pots (3 seedlings/hill, 3 hills in each) containing 7 kg mixed soil with cow-dung (3:1) in the open air with irrigation and NPK fertilizers as per Arnon and Hoagland (1940) two days before transplantation. For salinity stress 0.20 molal NaCl (25.2 dS.m⁻¹) was applied in treatment after 10 days following transplantation. It was comparable to sea water (22.7 dS.m⁻¹) and soil salinity of the coastal belt (3.86 - 27.1 dS.m⁻¹). Plant samples were harvested after 40 days. Ions were extracted from dried powdered plant material by 0.1 M acetic acid keeping in hot water bath (90°C) for 2h. Na⁺, K⁺ and Ca²⁺ were determined in the filtrate in flame photometer and Cl⁻ by titrimetric method. Protein, proline and root ATPase activity were measured following Lowry *et al.* (1951), Troll and Lindsley (1954) and Hodges (1976), respectively.

Salinity affected dry matter of rice seedlings in all cases and the inhibitory effect was more in root than shoot, and consequently decreasing the R/S ratio except Pokkali where root dry wt. and R/S ratio revealed an increasing trend. Tolerance index (TI) for dry wt. of the seedlings maintained the sequence: Pokkali > Nonabokra > BR 9 > IRATOM-24 (Table 1). The discriminatory effect of salinity stress on root-shoot growth and reduction of R/S ratio are known for a long time (Hanson and Hitz 1982), and now it is anticipated that such effect

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on root-shoot growth is due to altered carbon allocation, chloroplast metabolism, photosynthetic rate etc. and modification of carbohydrate metabolism, partitioning and transport (Gilbert *et al.* 1997). High dry wt. associated with high R/S ratio under stress may be considered important for salt tolerance as the inhibitory effect on these growth attributes were more pronounced in susceptible than resistant cultivars of the same crop (Alian *et al.* 2000). Intervarietal differences in dry matter yield were noted in the present work and variations in salt tolerance among species, varieties and cultivars were also noted by others (Yeo *et al.* 1990).

Salinity increased the level of Na^+ and Cl^- and decreased K^+ and Ca^{2+} in both root and shoot of the seedlings of all genotypes in different degrees (Table 1). Under stress the highest K^+ content, a positive character for salt tolerance, was observed in both root and shoot of BR 9. Pokkali and Nonabokra - the two known salt tolerant varieties revealed low K^+ content and compared to others they had also relatively low Na^+ content, but the shoot of BR 9 had the highest Na^+ content along with K^+ . Excepting IRATOM-24, in other cases Ca^{2+} in the root was almost similar, but in the shoot the sequence was: Pokkali > BR 9 > IRATOM -24 > Nonabokra. BR 9 had relatively higher Cl^- content in both root and shoot than others. Enrichment of Na^+ and Cl^- contents accompanied the reduction of macronutrients (K, Ca, P etc.) absorption and ion ratios in crop seedlings were reported (Bohra and Kodeffling 1993). Salinity affects K^+/Na^+ ratios and the presence of high K^+/Na^+ discrimination trait in a plant is of significance for its salt and sodicity tolerance (Gorham 1993). Salinity stress reduced Ca^{2+} and K^+ absorption in the present work while calcium plays dominant role in root elongation and maintenance of high K^+ level under salt stress (Nakamura *et al.* 1990). Low Cl^- content could be an important factor for salt tolerant plant (Rogers and Noble 1992). Accumulation of nutrients under salt stress contributes to osmotic adjustment of the plant (Santa-Cruz *et al.* (1999). Salinity, increased proline content (%) in the seedlings, more in root than shoot in most of the cases (Table 2). Treatment increased it in Pokkali in both root and shoot and only in shoot of IRATOM-24 more than others. Cachorro *et al.* (1993) observed significant increase of total sugar and proline contents in bean under high salinity. In the present work increase of proline was associated with that of Na^+ content in all genotypes. Proline is important for osmotic adjustment related to the accumulation of Na^+ in plant tissue (Dubey and Rani 1990). Protein was increased under salinity in all varieties except BR-9, the highest increase (%) was in IRATOM-24, which was followed by Nonabokra and Pokkali (Table 2). Salinity decreases protein synthesis in crop plants, but stimulatory effects are also known. Under stress Nonabokra and Pokkali could utilize their enhanced protein synthesis rate for their adaptive purposes (Dell'Aquila and Spada 1993) in general and cell membrane protein of crop plants in particular (Alamgir 1995). Plasma membrane lies on the border line and be involved in triggering cellular defense mechanisms in which stress proteins are associated.

ATPase activity was inhibited by NaCl in all cases except Pokkali, in the sequence: Nonabokra > IRATOM- 24 > BR 9 (Table 2). Because of its possible function in ion transport and energy transduction, high ATPase activity under stress may help to develop the stress tolerance activity of the plant, although its molecular mechanism is poorly understood (Lutge 1993). ATPase as a membrane component, membrane carrier and energy transducer may perform a vital role in the adaptive and tolerance mechanism of plant under stress.

It is evident that a single mechanism may not be effective for the overall salt tolerance efficiency, but the cumulative effect of a number of factors that are associated with biomass production potential, R/S ratio, relatively higher efficiency for the accumulation of K^+ and Ca^{2+} than Na^+ and Cl^- , high K^+/Na^+ ratio, lower rate of Na^+ transport to shoot, high proline and protein contents, membrane integrity and high membrane ATPase activity be involved in the development of salt tolerance efficiency.

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